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Dwarf galaxy candidates found on the SERC EJ sky survey

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Abstract. We inspected a sky region with declination range of $[0°, -18°]$ based on the SERC EJ plate copies. As a result a list of 50 nearby dwarf galaxy candidates with angular diameters $\geq 0'.5$ is presented. Most of the galaxies have low and very low surface brightness. More than 60% of the objects are detected for the first time.

Key words: dwarf galaxies

1. Introduction

Low surface brightness (LSB) dwarf galaxies are believed to be the most numerous galaxy population in the Universe. They are recognized as ideal laboratories to study star formation in different types of galaxies, the evolution of the interstellar medium, and the amount and nature of galactic dark matter; they also represent a key element in studies of galaxy formation and evolution in general. LSB dwarf galaxies are difficult to detect because their surface brightness is typically only a few percent above the dark night sky. For this reason their total number remains unknown even within the Local Group boundaries, not to mention the Local Supercluster and beyond. Some authors believe that ∼90% of all galaxies have surface brightness below the currently achieved detection limit (Disney & Phillips 1983; McGaugh 1996).

Systematic all-sky searches for LSB dwarfs began after the public distribution of the first photographic survey of the Northern sky (= POSS-I), which covers a sky area at declinations $D > -30°$ (van den Bergh 1959, 1966; Karachentseva 1968, 1972, 1973). Also many dwarf galaxies were found when general galaxy catalogues, such as MCG (Vorontsov-Velyaminov et al. 1962), UGC (Nilson 1973), UGCA (Nilson 1974) were compiled based on the POSS-I.

A special search for LSB dwarfs in the southern sky has been conducted by Feitzinger & Galinsky (1985) on the ESO/SERC sky survey covering a sky area below $-18°$. A large number of LSB dwarfs entered in the catalogues by Lauberts (1982) and Arp & Madore (1987) are based on that survey. Note that due to the better quality of photographic material used for the ESO/SERC survey, one may detect objects that are fainter and have lower surface brightness than those achievable with the POSS-I.

Different lists of LSB dwarf galaxies compiled before 1987 were reinspected by Karachentseva & Sharina (1988). After re-inspection of several thousand objects presented in different catalogues and lists, they compiled a catalogue of about 1500 LSB dwarf galaxies. The catalogue covers all the sky and has a characteristic depth of ~ 20 Mpc matching the Local Supercluster boundaries.

2. New steps in search for dwarf galaxy candidates

The Second Palomar Sky Survey (=POSS-II) covering the northern hemisphere, $[0° < D < +90°]$, together with the SERC Equatorial survey , $[0° < D < -18°]$, and the ESO/SERC survey, $[-90° < D < -18°]$, provide a unique opportunity to search systematically for LSB dwarfs on the homogeneous photographic material over the entire sky. This has already resulted in a recent discovery of the Andromeda dwarf satellites (Armandroff et al. 1998; Armandroff et al. 1999; Karachentsev & Karachentseva 1999), and the Local Group dwarf galaxy Cetus (Whiting et al. 1999).

One of the tasks to be performed on the new sky surveys has been a compilation of a complete and representative volume-limited sample of galaxies. To this end Karachentseva & Karachentsev (2000) have undertaken a search on the POSS-II and the ESO/SERC

⋆ Hubble Fellow.

Table 1. List of new dwarf galaxy candidates found in the SERC EJ zone

No	RA (1950.0) Dec.	$a \times b$		Type	SB	NED ident.	Notes
1	2	3		4	5	6	7
1	$00^h23^m38^s.5 - 11°19'50''$	$5'.0$	$4'.3$	Sph	VL	Cetus	LG member [1]
2	00 37 44.6 − 18 06 04	0.9	0.6	Sph/Ir	L	Scu 26	granulated
3	01 32 16.7 − 07 36 38	0.6	0.4	Ir	L	kdg 7	N615 $5'$ NE [2]
4	02 39 19.2 − 08 36 54	1.2	1.1	Sph	L		in N1052 gr.?
5	02 47 03.0 − 13 25 06	1.0	0.5	Ir	L		
6	04 27 59.2 − 14 18 56	0.9	0.4	Ir	L		
7	05 57 02.8 − 13 05 28	0.8	0.2	Ir	L		distant?
8	06 42 15.2 − 17 52 51	1.8	0.3	Ir	H	IC 2171	different V_h[3]
9	06 44 44.3 − 17 53 10	0.5	0.35	Epec	H	CGMW 1-0381	$V_h = 696$
10	07 10 28.9 − 07 44 12	1.0	0.25	Ir	L		
11	07 28 41.0 − 00 52 04	0.7	0.4	Ir	L		distant?
12	08 51 05.8 − 17 47 42	0.5	0.4	Ir	L		patchy
13	09 33 05.4 − 16 06 34	1.2	0.2	Ir	VL	VC,94	4 gal. $\sim 7'$ SW
14	09 37 55.0 − 03 39 30	1.1	1.0	Ir	L	PGC 27612	
15	09 52 40.9 − 06 02 00	1.3	0.3	Ir?	H	APMUKS	comp. N3115?
16	09 57 18.2 − 09 06 39	0.9	0.7	Ir?	VL		comp. N3115?
17	09 59 09.4 − 08 00 27	1.4	0.25	Ir	H	MCG-1-26-11	comp. N3115?
18	10 03 12.3 − 07 44 16	1.7	1.4	S0pec	H	NGC 3115dw1	$V_h = 698$
19	10 22 00.5 − 12 10 43	0.7	0.6	Ir	L		
20	11 02 06.3 + 00 19 40	0.5	0.4	Ir/Sph	L	APMUKS	comp. N3521?
21	11 03 01.7 − 01 35 36	1.7	0.8	Ir	L	UGC 6145	$V_h = 740$, c. N3521?
22	11 03 34.5 − 01 10 36	0.5	0.4	Ir?	L	APMUKS	comp. N3521?
23	11 03 42.2 − 14 08 04	3.5	1.2	Ir	L		
24	11 11 20.3 − 03 15 31	0.5	0.4	Ir	L	APMUKS	
25	11 42 45.5 − 16 59 46	1.2	0.7	Ir	VL		v. blue
26	11 51 18.3 − 14 44 51	1.8	1.1	Ir	VL		v. blue
27	12 19 30.9 − 09 31 23	0.8	0.3	Ir	L		distant?
28	12 21 22.0 − 14 40 34	1.2	1.0	Ir	EL		
29	12 34 38.4 − 10 13 21	1.4	0.6	Ir	L	PGC 42120	comp. N4594?
30	12 35 00.5 − 08 35 32	1.0	0.5	Ir	L		comp. N4594?
31	12 35 58.0 − 10 12 56	0.8	0.7	Sph	VL		comp. N4594?
32	12 37 18.3 − 11 28 35	0.6	0.5	Sph	EL		comp. N4594?
33	12 37 32.7 − 12 05 25	0.5	0.4	Sph	VL		comp. N4594?
34	12 38 42.7 − 11 39 12	0.8	0.7	Sph	VL		comp. N4594?
35	12 39 58.6 − 14 40 02	0.4	0.4	Ir	EL		bluish
36	12 44 02.8 − 03 48 10	0.9	0.65	Ir	L	kdg 198	
37	12 45 24.2 − 12 23 00	0.6	0.5	Sph?	VL		
38	12 50 56.6 − 05 39 25	1.2	0.5	Ir	L	APMUKS	
39	12 51 06.5 − 05 48 46	0.8	0.6	Sph	EL		
40	12 57 15.7 − 13 51 04	1.0	0.6	Ir	VL		
41	13 03 07.6 − 07 29 29	1.4	1.1	Ir	L	kdg 218	comp. N4948?
42	13 03 42.7 − 07 49 31	1.2	0.9	Ir	VL		comp. N4948?
43	13 06 39.6 − 17 05 55	0.7	0.5	Ir?	EL		
44	13 30 23.5 − 12 00 20	0.5	0.3	Ir	L		blue; distant?
45	14 11 06.0 − 01 57 12	0.6	0.4	Sph?	VL	kdg 230	distant?
46	14 25 47.0 − 08 41 55	0.5	0.5	Ir	L		distant?
47	14 32 38.5 − 16 56 43	1.8	0.9	Ir	L		
48	16 03 02.4 − 04 26 16	1.3	1.0	Ir	L		distant S?
49	16 40 45.7 − 07 58 00	1.1	0.4	Ir	L		distant?
50	17 39 00.1 − 04 35 59	1.3	0.5	Ir	L		distant S?

[1] Discovered by Whiting et al. (1999).
[2] Probably belongs to a group of NGC 584, 596, 600, 615 with the mean $V_h = 1850$ km s^{-1}.
[3] There are two different velocity estimates: $V_h = 3395$ km s^{-1}.
(Visvanathan & Yamada 1996), and $V_h = 784$ km s^{-1} (Theureau et al. 1998).

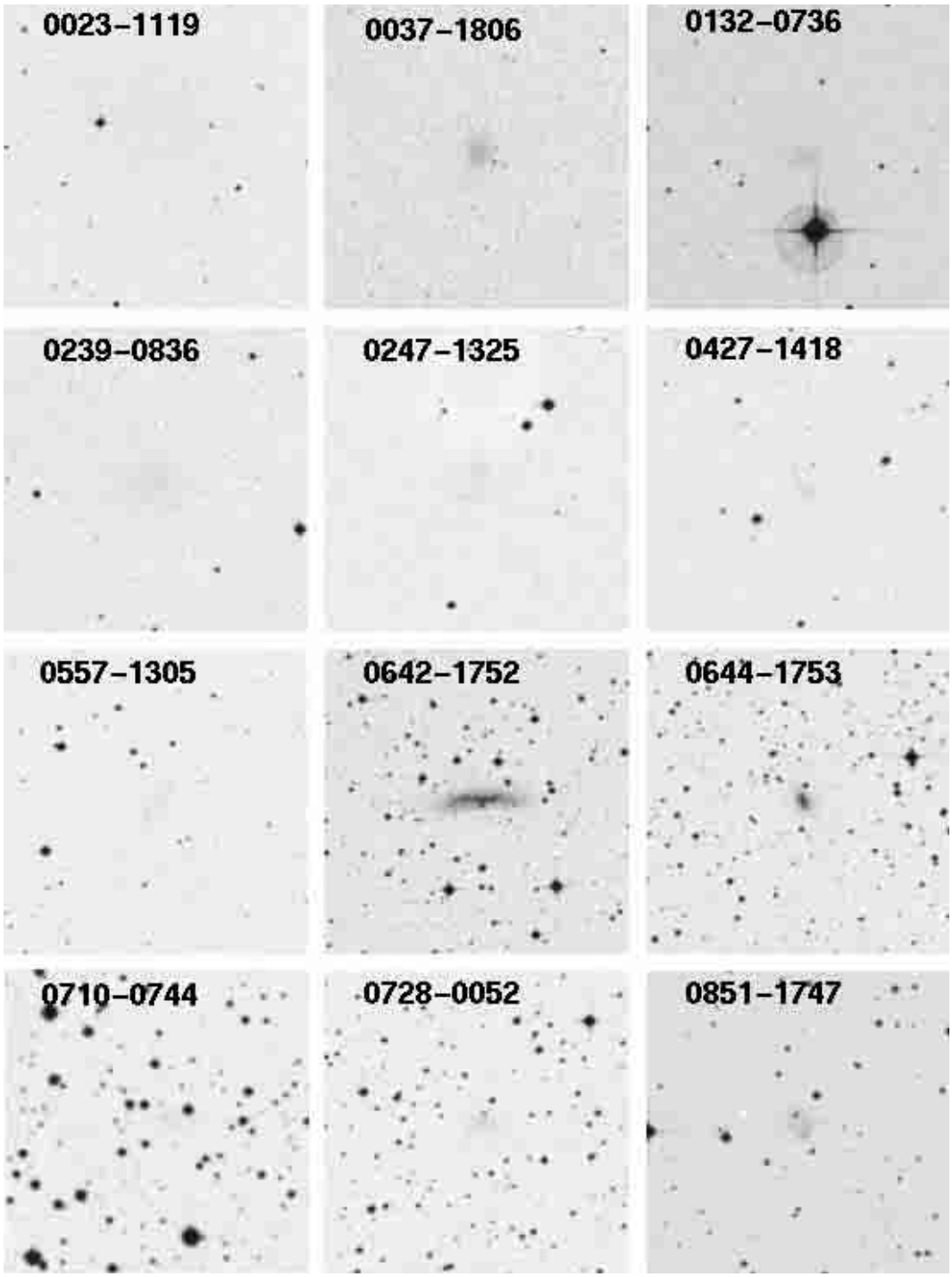

Fig. 1. Digital Sky Survey $5' \times 5'$ images of 50 dwarf galaxy candidates (continued in Figs. 2–5). North is up, and East is to the left

copies for LSB dwarf galaxy candidates with angular diameters $a \geq 0'.5$ around all the Local Volume (=LV) galaxies. The LV galaxies with corrected radial velocities $V_0 < 500$ km s^{-1} were taken from the list by Karachentsev (1994), which is an up-dated version of Kraan-Korteweg & Tammann's (1979) and Schmidt & Boller's (1992) catalogues of nearby galaxies. Altogether 260 nearby dwarf galaxy candidates have been found (henceforth referred to as kk-objects or kk-galaxies), more than a half of them previously uncatalogued.

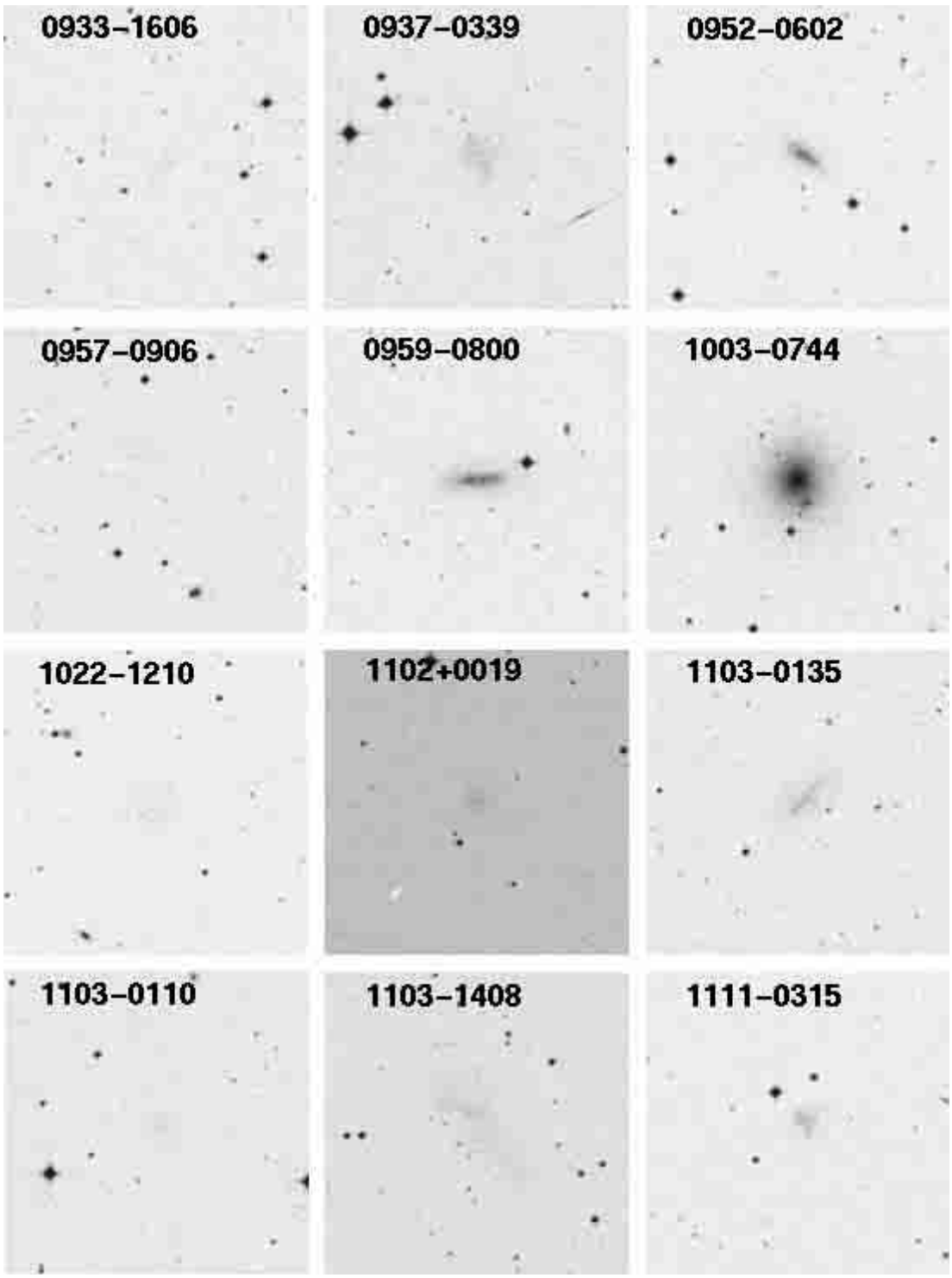

Fig. 2. Digital Sky Survey images of 50 dwarf galaxy candidates (continued from Fig. 1)

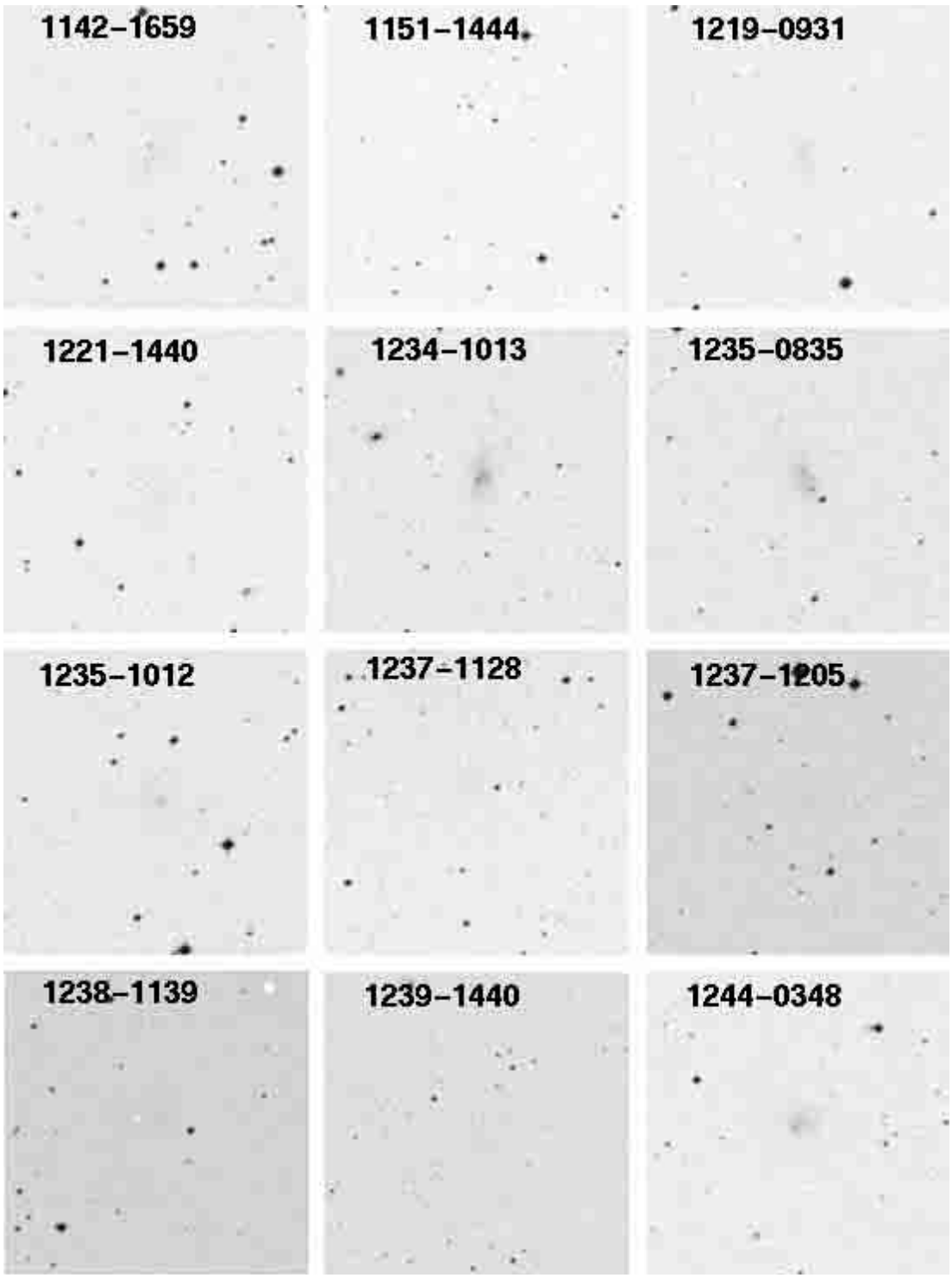

Fig. 3. Digital Sky Survey images of 50 dwarf galaxy candidates (continued from Fig. 1)

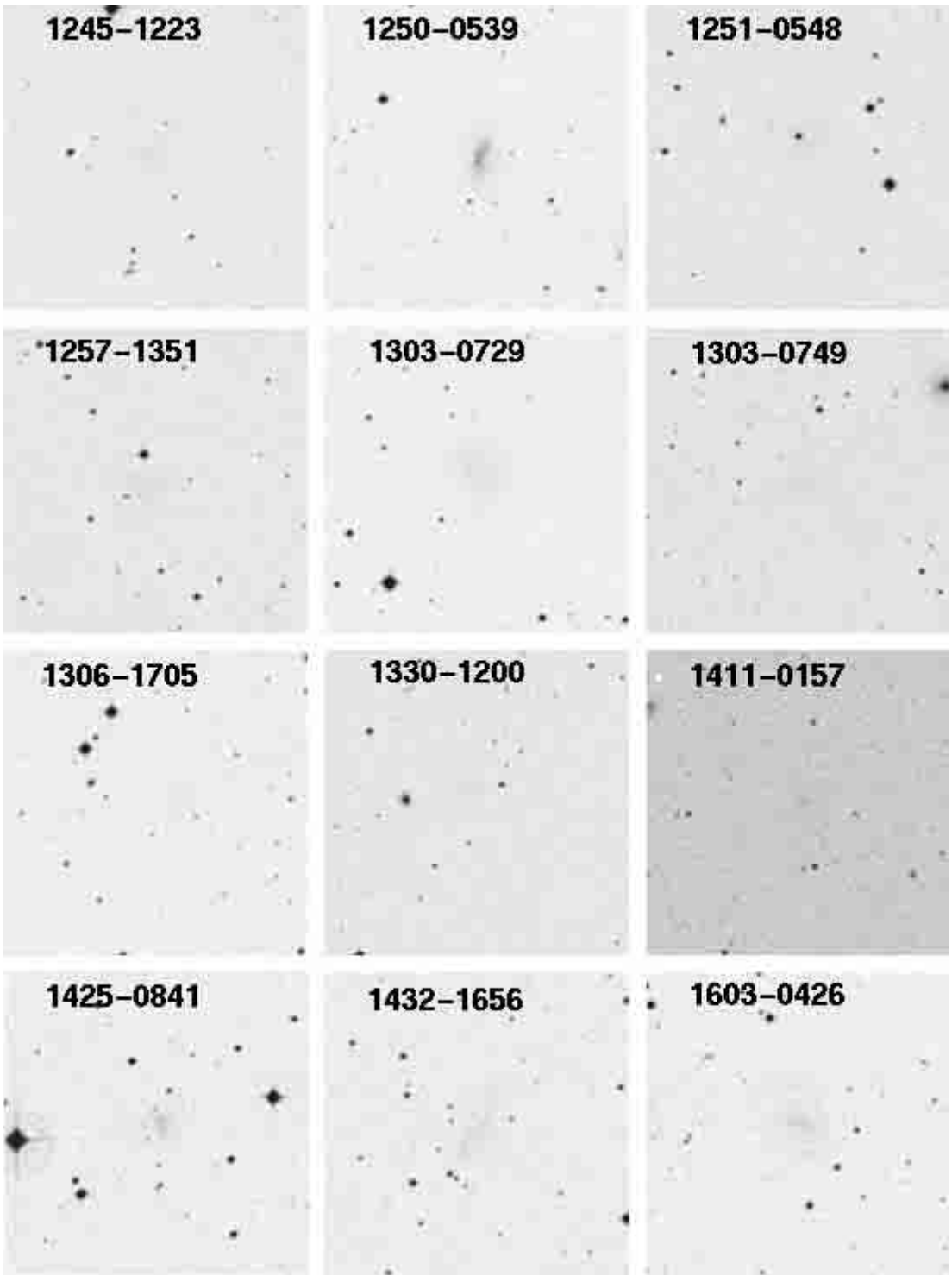

Fig. 4. Digital Sky Survey images of 50 dwarf galaxy candidates (continued from Fig. 1)

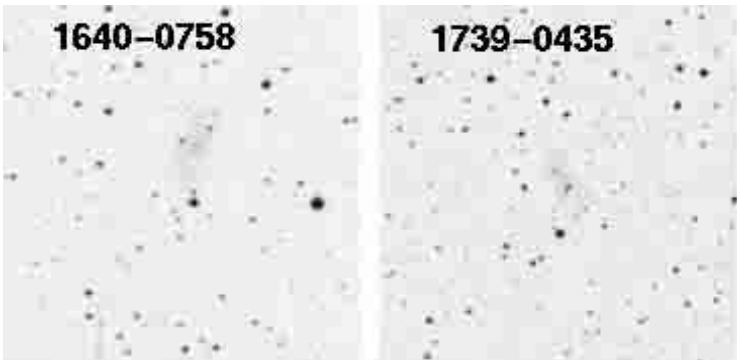

Fig. 5. Digital Sky Survey images of 50 dwarf galaxy candidates (continued from Fig. 1)

HI observations of the kk-objects with the 100-m Effelsberg radio telescope (Huchtmeier et al. 1997, 2000) have shown that:

1. the HI detection rate is about 60% (a rather high value taking into account that the kk-list contains a large number of dSphs);
2. the median radial velocity in the sample is about 1200 km s^{-1}, indicating that the kk-objects are mainly real dwarf galaxies;
3. there are 40 kk-galaxies with $V_0 < 500$ km s^{-1}, which essentially increases the LV sample.

The next steps involved the following:

1. A search for dwarf galaxy candidates in the Tully Local Void region, covering $\sim 6000\square^\circ$ area around $\{\mathrm{RA} = 18^\mathrm{h}38^\mathrm{m}, D = +18^\circ\}$, yielded new 78 objects (Karachentseva et al. 1999);
2. An overall search in the ESO/SERC sky region resulted in 81 dwarf galaxy candidates (Karachentseva & Karachentsev 2000);
3. An overall search on the POSS-II, the northern hemisphere (except the Virgo cluster region and the Local Void area), yielded 101 dwarf galaxy candidates (Karachentsev et al. 2000). Many of them have been observed by W. Huchtmeier with the Effelsberg radio telescope.

3. A list of dwarf galaxy candidates in the equatorial zone

The last step of the work has been accomplished on the J, F glass copies of the SERC Equatorial survey belonging to STScI. Altogether 216 both "blue" and "red" 6×6 degree plates have been inspected in the declination zones -5, -10, and -15° along with 5 equatorial POSS-II fields absent in our previous inspection. Similar to previous work, we selected dwarf galaxy candidates with angular diameters ≥ 5 by their low or very low surface brightness. Some of the high surface brightness objects were also taken into account.

After exclusion of emulsion defects, isolated Galactic cirrus, and probable distant "normal" LSB galaxies we have compiled the main list of 50 objects. This list is given in Table 1. The table columns contain:

(1) the running number;

(2) equatorial coordinates (epoch 1950.0);

(3) major and minor diameters measured visually on blue plates;

(4) the morphological type in usual designations ("d" for "dwarf" is omitted);

(5) a rough estimate of surface brightness (=SB): H − high (equal or brighter than the SB of a normal spiral galaxy, 22 − 23 mag arcsec^{-2}), L − low (23 − 24 mag arcsec^{-2}), VL − very low (24 − 25 mag arcsec^{-2}), EL − extremely low (25 − 26 mag arcsec^{-2});

(6) galaxy name in other catalogues and lists as given in the NASA Extragalactic Database (=NED);

(7) comments concerning morphology, galaxy membership, etc.

Note, that the object #1 (Cetus) was found by us independently from Whiting et al. (1999). In this paper, which was devoted to the discovery and detailed investigation of the Cetus LG galaxy, the authors reported the finding of 75 new VLSB dwarfs in a sky region at $D < 3^\circ$ covered by the ESO/SERC and SERC EJ surveys. Unfortunately, we were unable to compare our list of objects with their unpublished list.

Figures 1–5 displays $5' \times 5'$ images of 50 dwarf galaxy candidates taken from the Digital Sky Survey.

In Table 2 we give for comparison a list of other 17 LSB objects, which were isolated using the same criterion but exhibited radial velocities in excess of 500 km s^{-1}. The table columns provide the same quantities as in Table 1. We added only two columns, with total magnitude, B_t, and heliocentric radial velocity, V_h, from NED. According to the NED data, all objects in Table 2 were catalogued

Table 2. Other candidates selected with the same criterion and rejected due to their velocities

No	RA (1950.0) Dec.	$a \times b$		T	SB	NED Ident.	B_T	V_h	Notes
51	$02^h31^m28^s.0 - 06°34'44''$	0.′8	0.′4	Ir	L	P09774	—	1407	knot
52	02 46 50.9 − 02 51 43	0.9	0.5	Ir?	L	UGC A44	—	1094	
53	04 06 39.3 − 08 45 28	1.0	0.6	Ir	L	P14562	—	894	
54	05 39 36.7 − 12 35 09	1.0	0.4	Sm	L	P17621	—	2245	
55	05 47 55.8 − 10 18 45	2.0	0.9	SB?	L	P17965	—	895	
56	05 49 44.0 − 11 09 05	0.9	0.8	Ir?	L	P18027	15.5	903	pair w.#55
57	08 41 04.4 − 17 12 15	1.8	0.5	Ir	L	P24494	—	2019	knots
58	10 50 29.1 + 02 45 33	1.5	0.5	Ir	L	L135768	17.4	1054	
59	11 10 13.9 − 00 17 39	0.5	0.4	Ir	L	ISI, 96	17.8	8472	patchy, blue
60	12 20 35.1 − 13 40 05	1.4	0.9	Ir	L	UGC A278	—	1155	knots
61	12 42 18.7 − 08 51 15	4.0	1.8	Sm	L	UGC A295	—	1378	
62	12 56 29.6 − 11 57 31	1.2	0.8	Ir	L	UGC A312	—	1307	
63	13 23 43.5 + 02 43 06	0.8	0.4	Ir	L	ISI, 96	16.8	1137	blue
64	13 25 39.4 + 02 32 20	0.8	0.45	Ir	L	ISI, 96	16.3	1221	$\sigma_v = 275$
65	14 11 47.0 − 02 47 59	0.8	0.25	Ir	L	ISI, 96	15.8	1853	$\sigma_v = 275$
66	14 31 20.7 + 01 42 14	1.0	0.2	Ir	L	ISI, 96	17.4	1829	
67	20 06 41.4 − 06 26 05	2.2	1.4	S	L	UGC A417	—	1425	

ISI, 96 = Impey et al. (1996).

earlier, and their radial velocities together with their angular extent and low surface brightness confirm that these are dwarf galaxies.

4. Concluding remarks

In the sky region covered by the SERC Equatorial survey, we have found 50 low and very low surface brightness objects. Most of them presumably are nearby dwarf galaxies. More than half of these objects were previously uncatalogued. The presented results increase the number of possible dwarf companions around the nearby giant galaxies NGC 3115 and NGC 4594.

This work completes the entire-sky search for nearby LSB dwarf galaxy candidates. A total of ∼ 600 objects have been found, half of them for the first time. The HI observations of these objects carried out by W. Huchtmeier confirm that most of them are really dwarf galaxies located in the Local Supercluster.

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